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APPLICATION NOTE

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EXTENDING THE RANGE OF AN INTERMODULATION DISTORTION TEST

More often than not, a system's intermodulation distortion is characterized by its third-order intercept value, the most widely accepted figure of merit for indicating the linearity of a system. Even though IMD is extremely difficult to measure accurately and with repeatability when low signal levels are introduced into the device under test, precise measurements can be made at levels as low as 100 decibels below the desired carrier (input signal) point. The secret is to add a tunable bandpass filter to the measuring system and to reduce the nonlinearities inherent in the test system, thus making it possible to determine third-order intercept values of up to +50 dBm, which is more than 20 dB above that of most measuring systems now in use.

Third-order intermodulation products are generated as shown in part (a) of the figure. Consider two signals, f_1 and f_2, that are applied to the input of a device that has a non–linear transfer function. If the output power is equally distributed at both frequencies and the frequencies are close together, equal power-distortion products will occur at $2f_1 – f_2$ and $2f_2 – f_1$.

The magnitude of these unwanted products, expressed in decibels below the output P_0, is defined as the system IMD. The third-order intercept may then be found by its defining equation:

$$I = P(dBm) + IMD(dB)/2 \qquad (1)$$

where IMD is the third-order product produced by the I intercept value, measured in decibels.

An IMD setup having wide dynamic range is shown in (b). In this case, measurements are performed at 30 to 500 MHz, although the guidelines set forth here will allow accurate measurements at any frequency.

The first step in measuring IMD and thus securing the third-order intercept of a device is frequently the most difficult to attain — that of combining two input tones to the device under test without introducing distortion or spurious responses. For fixed-input-frequency setups, filters can be employed to eliminate harmonics generated by f_1 and f_2. If the input frequencies are variable, cavity oscillators should be used instead of sweep generators, because the alters harmonic content is too high.

The best method for combining the two signals linearly is to use a resistive power combiner as shown, so that the composite signal generated will be virtually clean (no nonlinearities). To reduce third-harmonic distortion between the f_1 and f_2 generators, 10 dB attenuator pads should be used between the cavity oscillators and the power combiner. Using both the pads and the combiner guarantees a broadband input source with constant characteristic impedance facing the device under test. As the requirement for a broadband resistive source of constant impedance also applies to the load for the test device, it is wise to use a 10 dB attenuator here, as well.

The system's measuring range is improved by placing a five-pole bandpass filter in the postamplifier chain. Having a bandwidth of less than $\Delta\phi$, this filter rejects unwanted signals f_1, f_2, thus eliminating strong but unwanted signal responses that tend to limit the dynamic range of (that is, desensitize) the test system.

For those not familiar with the procedure, IMD and third order intercept are found as follows:

- Set channel spacing to the desired Δf (6 megahertz for the system shown in the figure).
- Set reference signal f_3 to $2f_1 – f_2$.
- Using a power meter, set P_0 to the desired output power level for each of the three sources independently. Connect only one source at a time.
- With f_3 connected, tune the bandpass filter to f_3. With the variable attenuation at 30 to 50 dB, set a reference level on the spectrum analyzer. Make sure the postamplifier is not in compression by inserting 30 to 50 dB of additional attenuation. One should then observe 30 to 50 dB of signal reduction on the spectrum analyzer.
- Apply f_1 and f_2. Decrease attenuation in the variable attenuator to bring the signal within range of the analyzer. Add the change in attenuation to the value of suppression as read on the analyzer to obtain IMD.
- Adjust f_3 and filter to $2f_2 – f_1$ and repeat all steps. IMD should be within 3 dB of the first measurement.
- Calculate the third-order intercept from Eq. 1.

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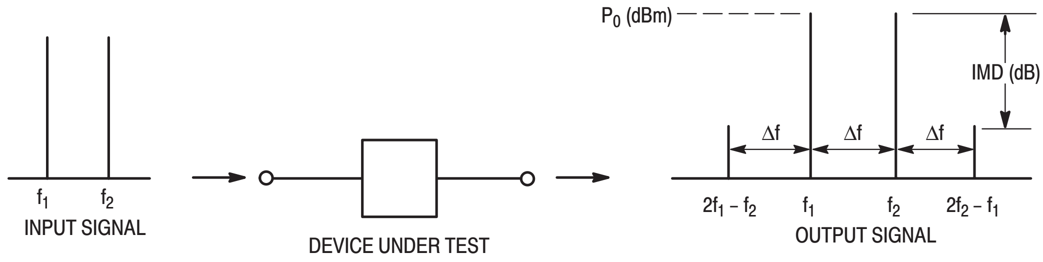
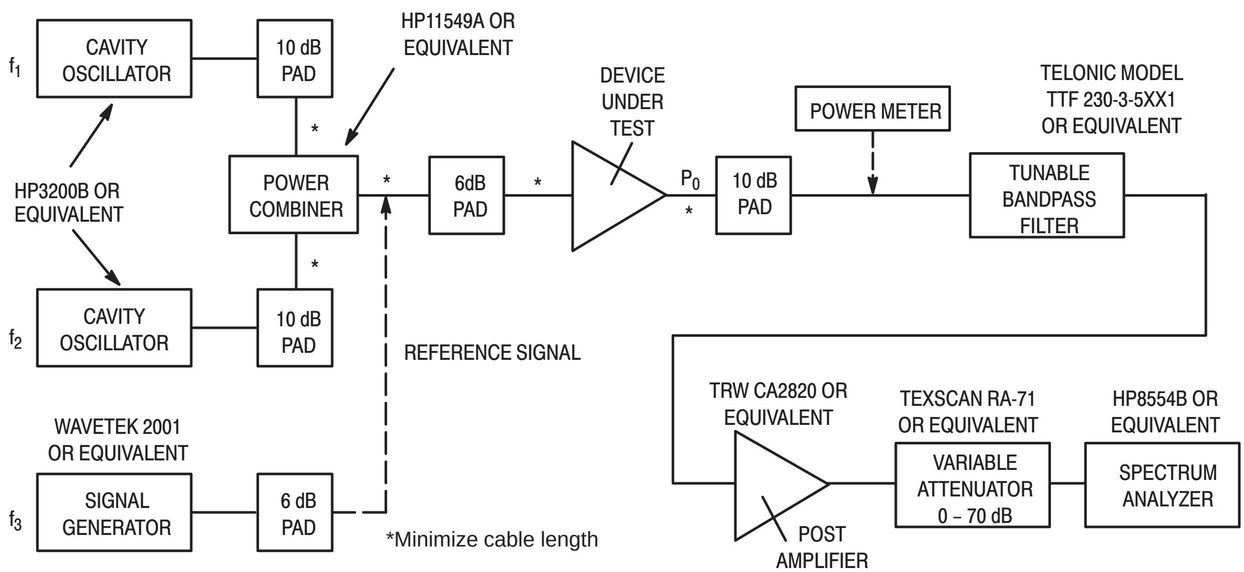


(a)



(b)

Wide range. Intermodulation distortion is created if two input frequencies pass through a nonlinear device (a). System measures IMD over wider range than standard setups by using cavity oscillators to reduce harmonic generation, tunable bandpass filter for rejection of IM components not measured against f_1, or f_2 ($2f_2 - f_1$ or $2f_1 - f_2$, respectively), and power-splitter for linear combiner of f_1 and f_2. Pads (6 dB and10 dB) offer isolation between system elements. With setup, measurements of IMD can be made at levels 100 dB below carrier.

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